NON-PROVISIONAL APPLICATION FOR UNITED STATES PATENT

FOR

MARKING ON UNDERFILL

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MARKING ON UNDERFILL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to, but is not limited to, electronic devices, and in particular, to the field of integrated circuit packaging.

2. Description of Related Art

Integrated circuits are often assembled into packages that may be mounted onto a printed circuit board. Such packages may include a substrate that has solder balls or other types of contacts that are used to couple the substrate to the circuit board. An integrated circuit, such as a die or chip (herein "die"), may be mounted onto the substrate, the die or chip being electrically coupled to the substrate by way of solder bumps or other contact types. Other components such as capacitors and resistors may also be mounted on top of the substrate. Further, the substrate will typically have routing traces, vias and the like, that electrically connects the die to the solder balls or equivalent contacts.

In some cases, a protective or a structural-supporting layer called an underfill may be placed between the die and the substrate. For example, one type of die that is currently being incorporated into integrated circuit packaging is the flip-chip. Flip-chips are chips that are inverted and connected directly to the packaging substrate (or circuit board) rather than using the more common wire bonding techniques. Typically when a flip-chip is mounted onto the packaging substrate, an underfill is inserted between the die and the substrate. The underfill is usually an epoxy material that may structurally reinforce the solder bumps that are located underneath the die and may improve the life and reliability of the package.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be described by way of exemplary embodiments, but not limitations, illustrated in the accompanying drawings in which like references denote similar elements, and in which:

FIG. 1 illustrates a die mounted on a substrate with a marking on an exposed portion of an underfill according to one embodiment of the invention.

FIG. 2 illustrates a die mounted on a substrate with a marking on an expanded exposed portion of an underfill boarded by an underfill barrier according to another embodiment.

FIG. 3 illustrates a particular embodiment of **FIG. 2** of a die mounted on a substrate with marking on an expanded exposed portion of an underfill bordered by an underfill barrier, in particular, a dam underfill barrier according to an embodiment.

FIG. 4 illustrates a flow chart for forming an integrated circuit package with a marking on an underfill according to some embodiments.

FIG. 5 is a block diagram of an example system, according to some embodiments of the invention.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

In the following description, for purposes of explanation, numerous details are set forth in order to provide a thorough understanding of the disclosed embodiments of the present invention. However, it will be apparent to one skilled in the art that these specific details are not required in order to practice the disclosed embodiments of the present invention.

One current trend in integrated circuit technology is to reduce the size of integrated circuit packaging. This may be particularly true in the fields of portable personal computers and handheld electronics. Such devices may have very limited space for components and there is a trend to make these devices smaller with more functionality. As a result, there is increasing pressure to decrease the size of the components that go into these devices while increasing the number of these components, including integrated circuit packages (herein "packages").

In order to decrease the size of packages, package components (e.g., dies, capacitors, resistors and the like) may be closely packed together leaving little space for placing a marking. A marking may include any type of symbols, text and/or bar codes that may provide information relating to, for example, component identification, component specification, or any other type of information that may be useful. Among conventional approaches for placing markings is to place the markings on the die backside or designate an area on the surface of the substrate for markings.

According to some embodiments of the invention, markings may be placed on an exposed portion of an underfill. Referring to **FIG. 1**, which depicts a package with markings placed on an underfill according to one embodiment. For the embodiment, a die **102**, such as a flip-chip, is mounted on a substrate **104**. Between the die **102** and the substrate **104** is an underfill **106**. The underfill **106** may have an exposed portion **108** where a marking **110** may be placed. Although not shown, the substrate **104** may comprise of other components such as capacitors, resistors, and the like.

According to some embodiments, the expose portion **108** may be the underfill tongue, which is the underfill site where a dispenser may have been placed to deposit an underfill material for forming the underfill **106**. That is, in some embodiments, in order to form the underfill **106**, a dispenser, such as a capillary, may be placed near the

die **102**. The dispenser may then deposit the underfill material (which may initially be in liquid or semi-liquid form) on to the surface of the substrate **104**. After the underfill material has been deposited on the surface of the substrate **104**, the dispenser may be retracted leaving behind a relatively large exposed underfill area (i.e., underfill tongue) that is outside the die **102** (i.e., not covered by the die). For these embodiments, this underfill tongue area may not be available for other components because of the presence of the underfill material on the surface of the substrate, which may prevent good electrical contact between the components and conduction pads (e.g., solder lands or surface pads) on the substrate surface. Thus, this underfill tongue area may remain unused.

According to some embodiments, a marking **110** may be placed on this unused underfill tongue area or other exposed underfill portions having sufficient exposed area for a marking. The marking **110** may be but are not limited to laser markings, ink markings, decal markings, and the like. The marking **110** may be in the form of text, numerals, symbols, and/or any other writing forms. The information provided by a marking may be related to component identification, component specification and/or any other type of information.

As previously described, the underfill material that is used to form the underfill **106** may be initially in liquid or semi-liquid form. The underfill 106 may have adhesive properties to bond the die **102** to the substrate **104** and/or structural integrity to protect die and substrate connections (e.g., solder bumps and connections). Additional material may be added to the underfill 106 to produce desirable properties such as pigmentation that may give greater contrast to subsequent markings. According to some embodiments, the underfill **106** is an organic polymer that may contain inorganic fillers used to modify the mechanical properties of the cured material.

The substrate **104**, which may comprise of vias and traces, may be an integrated circuit packaging substrate such as but are not limited to Ball Grid Array (BGA), Organic Land Grid Array (OLGA), Flip-chip Pin Grid Array (FC-PGA), and the like. Although not shown, the substrate **104** may further be mounted onto a circuit board or the substrate **104** may itself be the circuit board.

Referring now to **FIG. 2**, which depicts an underfill **106**, having an enlarged exposed portion **108** according to another embodiment. For the embodiment, an underfill barrier **112** is on the surface of the substrate **104** bordering the underfill **106**. The underfill barrier **112** may be used during the formation of the underfill **106** to restrict the underfill material to a specific area on the surface of the substrate **104**. The underfill barrier **112** is extended away from the die **102** to enlarge the exposed portion **108** thus providing a greater area for placing a larger marking **110**. The enlarged exposed portion **108** may be the underfill tongue area or other exposed portions of the underfill **106**. According to some embodiments, the exposed underfill area **114** at the bottom of the die **102** may be enlarged to provide a marking location that is separate from the underfill tongue location. Thus, enlargement of the underfill **106** is not restricted to the underfill tongue location (e.g., the location where the dispense capillary was originally placed). Note that although for the embodiment, the underfill barrier **112** completely encircles the underfill **106**, in other embodiments, the underfill barrier **112** may not completely encircle the underfill **106**. That is, the underfill barrier **112** may be used to only restrict the underfill **106** from spreading to certain areas of the substrate surface.

Various implements may be used as underfill barrier **112**. According to some embodiments, implements such as but not limited to, a dam, a trench and/or an ink border, may be used as the underfill barrier **112**. These barriers may also be used in combination to provide greater control over underfill material spread. **FIG. 3** depicts a cross sectional view of an underfill dam **302** used to control the spread of underfill material. For the embodiment, the underfill dam **302** facilitates the formation of a large exposed portion **108**. The die **102** is on solder bumps **304**, which may sit on conduction pads (e.g., solder lands or surface pads) **306** of the substrate **104**.

FIG. 4 is a process **400** for creating a marking on an exposed portion of an underfill according to some embodiments. The process **400** may begin when a die **102**, such as a flip-chip, is mounted onto a substrate **104** at **402**. According to some embodiments, the die**102** may be placed onto solder bumps **304** on top of the substrate **104**. For these embodiments, the solder bumps **304** may be formed by electroplating or by deposition and subsequent reflow of the solder paste

After mounting the die **102** to the substrate **104,** an underfill barrier **112** may be formed to control the spread of underfill material at **404**. As previously described, the underfill barrier 112 may be a dam, a trench, an ink boarder or a combination thereof. In other embodiments, the underfill barrier **112** may be formed in the substrate prior to chip attachment. In yet other embodiments, the process for forming an underfill barrier **112** may be disregarded.

Following the process for forming the underfill barrier **112**, underfill material may be dispensed on to the surface of the substrate at **406**. According to one embodiment, this may be accomplished by placing a dispenser, such as a capillary, near the die **102** and within the underfill barrier **112** and injecting the liquid or semi-liquid underfill material onto the surface of the substrate **104**. The underfill material may then spread within the substrate surface area that may be completely or partially bordered by the underfill barrier **112** and may or may not completely fill the void spaces between the die **102** and the substrate **104**. In order to ensure that the exposed portion **108** of the underfill **106** will have sufficient underfill material (i.e., sufficient underfill material will cover the substrate surface where the marking will be placed), dispense parameters such as underfill material weight and composition, dispenser distance from the chip edge, barrier location and dispenser nozzle size, may be adjusted.

After dispensing the underfill material onto the surface of the substrate, the underfill material may be cured at **408**. Such processes are known in the art and may include the use of a curing furnace or oven. Once the curing process is completed, the underfill **106**, which may comprise of an epoxy material, may take on certain pigmentation. In some embodiments, the underfill may include coloring that will provide a good contrast to markings that may be subsequently placed onto the underfill **106**. In one embodiment, the cured underfill **106** is opaque. The pigmentation of the underfill **106** may depend upon the composition of the underfill material. Thus, desirable pigmentation for the underfill **106** may be obtained by controlling the composition of the underfill material such as by including additives.

After curing the underfill, a marking **110** may be placed onto the exposed portion **108** of the underfill **106**. As previously described, the placing of the marking **110** may

be accomplished using different techniques such as laser marking, ink marking, decal marking and the like.

Referring to **FIG. 5** showing a system **500** in accordance with some embodiments. The system **500** includes a microprocessor **502** that may be coupled to a bus **504**. The system **500** may further include a temporary memory **506**, a network interface **508**, and a RF transceiver **510**. In an alternative embodiment, the RF transceiver **510** may be part of the network interface **508**. One or more of the above enumerated elements, such as microprocessor **502**, memory **506**, and so forth, may contain one or more of the integrated circuit packages that advantageously incorporate the underfill markings described above. In alternate embodiments, other components, such as a chipset may also include the underfill markings described above.

Depending on the applications, the system **500** may include other components, including but not limited to non-volatile memory, chipsets, mass storage (such as hard disk, compact disk (CD), digital versatile disk (DVD), graphical or mathematic co-processors, and so forth.

In various embodiments, the system **500** may be a personal digital assistant (PDA), a wireless mobile phone, a tablet computing device, a laptop computing device, a desktop computing device, a set-top box, an entertainment control unit, a digital camera, a digital video recorder, a CD player, a DVD player, a network server, or device of the like.

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that any arrangement which is calculated to achieve the same purpose may be substituted for the specific embodiment shown. This application is intended to cover any adaptations or variations of the embodiments of the present invention. Therefore, it is manifestly intended that this invention be limited only by the claims.